

## Titan Submarine: Exploring the Depths of Kraken Mare

Completed Technology Project (2015 - 2017)

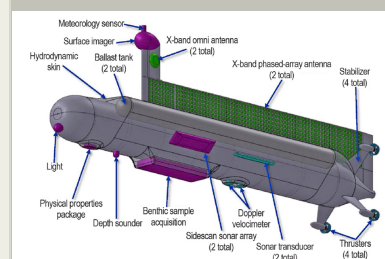


## Project Introduction

Phase II of the Titan Submarine: Exploring the Kraken Mare effort will focus on advancing the Technology Readiness Level (TRL) of the concept by (1) retiring risks found in the Phase I design, (2) gathering new Kraken Sea observations by Cassini, and (3) further defining science goals and instruments to fulfill them; each of these tasks will feed into two COMPASS design sessions. All of these products should ready the Titan Submarine (Titan Sub) concept to a confidence level that allow further NASA investment. The major risks found in the Phase I conceptual design center around vehicle operations in a liquid hydrocarbon sea. Basic physics questions of operating in this cryogen need to be answered. Cryogenic experts at the NASA Glenn Research Center will develop models to explore mixtures and pressures of cryogens and gases and how they would react with a warm submarine. Results from these models will be used to refine the ballast and propulsion system conceptual designs as well as feed into development of a hydrodynamic fluid models at the Pennsylvania State University Applied Research Laboratory for evaluating the conceptual design. Cassini continues to observe both the constituents (remotely) and the depth of the northern Titan Seas. Up-to-date data will be gathered and used as inputs for the modeling mentioned above. These data, along with the above analysis results, will be used to refine the science goals, concept of operations, and instrument suite for the Titan Sub. These activities will be led by the Johns Hopkins University Applied Physics Laboratory. The Phase II efforts will be strengthened by workshops at selected science and cryogenic conferences that will include scientists, cryogenic engineers (including the liquid natural gas industry) respectively, as well as NASA project planners to review the Titan Sub concept and add direction and experience to the challenges it faces. The results of both the above efforts will feed into a COMPASS current engineering design run to update the current Titan Sub conceptual design to mature the concept. Launch and delivery options will be explored (in Phase I funds were not sufficient to design more than the Sub itself) on how to deliver this long cylindrical submarine. Risks of an exposed phased-array antenna to communicate directly back to Earth will also be explored. A second COMPASS run will develop a Titan Sub that would be delivered as part of an orbiter system. The presence of an orbiter would greatly simplify several aspects of the submarine design, especially delivery and communications.

## Anticipated Benefits

The Titan Sub Phase II study will have several wider benefits: The results of Phase I have already engaged the public with a multitude of news stories, both on the Web and local news programs, with half a million hits on its concept video.<sup>17</sup> Most notable is the BBC article<sup>18</sup> Is Titan Submarine the Most Daring Mission Yet? In addition, the cryogenic Sub's technologies will certainly have impact on the LNG community in the form of pumps, seals, and alternative operating environments. Regardless of the eventual launch date of a Titan submarine, there are several immediate scientific and engineering



Artist depiction of Titan Submarine

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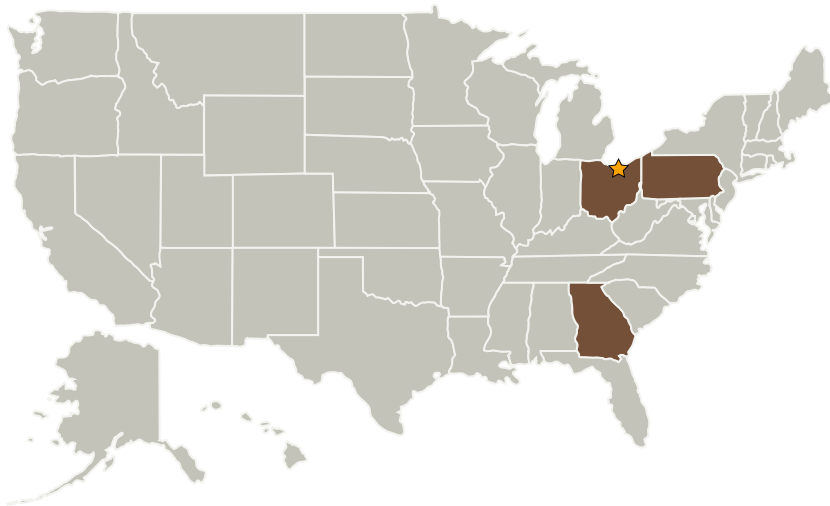
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benefits to the Phase II research, including (1) better understanding of the seas of Titan with the cryogenic modeling tasks, (2) solutions on delivery and operation of extraterrestrial submersibles for other moons, and (3) cryogenic concepts for both NASA's cryogenic fluid management research (cryogenic motors, valves seals, pumps, and instrumentation) and the LNG community.

## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Glenn Research Center(GRC)	Lead Organization	NASA Center	Cleveland, Ohio
Georgia Tech Research Corporation(GTRC)	Supporting Organization	Academia	Atlanta, Georgia
Johns Hopkins University	Supporting Organization	Academia	Baltimore, Maryland

## Primary U.S. Work Locations

Georgia	Ohio
Pennsylvania	

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Glenn Research Center (GRC)

**Responsible Program:**

NASA Innovative Advanced Concepts

## Project Management

**Program Director:**

Jason E Derleth

**Program Manager:**

Eric A Eberly

**Principal Investigator:**

Steven R Oleson

**Co-Investigators:**Michael S Paul  
Jason W Hartwig  
Justin M Walsh  
Robert Braun  
Ralph D Lorenz

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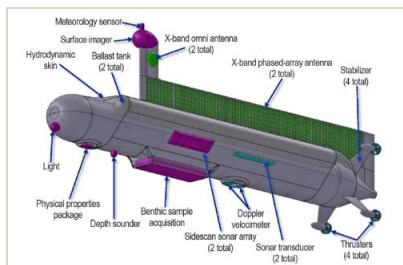
## Project Transitions

**July 2015:** Project Start

**June 2017:** Closed out

**Closeout Link:** <https://www.nasa.gov/feature/titan-submarine-exploring-the-depths-of-kraken-mare>

## Images



### Project Image

Artist depiction of Titan Submarine  
(<https://techport.nasa.gov/image/102175>)

## Links

NASA.gov Feature Article  
(<https://www.nasa.gov/feature/titan-submarine-exploring-the-depths-of-kraken-mare>)

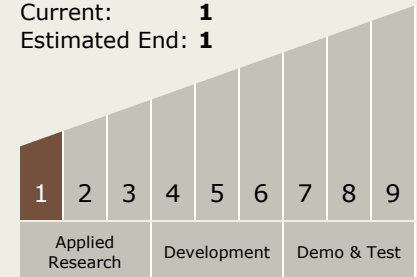
Seven Hundred Leagues Beneath Titan's Methane Seas  
(<https://www.nytimes.com/2021/02/21/science/saturn-titan-moon-exploration.html>)

### Project Website:

<https://www.nasa.gov/directorates/spacetech/home/index.html>

## Technology Maturity (TRL)

Start: **1**  
Current: **1**  
Estimated End: **1**



## Technology Areas

### Primary:

- TX14 Thermal Management Systems
  - TX14.1 Cryogenic Systems
    - TX14.1.2 Launch Vehicle Propellant

## Target Destination

Outside the Solar System